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DIRECTIONAL SEDIMENTARY STRUCTURES IN RECENT TUFFS, TOWER HILL, AUSTRALIA.

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Abstract: Differences in movement-directions of climbing-ripple cross-lamination relative to initial dip orientation are used to demonstrate that the Tower Hill tuffs were deposited by wind action rather than from a slurry. The dominant wind trend is shown to have been north-east to south-west, while the dominant wind direction was south-west, a direction in accordance with contemporary prevailing wind records.

INTRODUCTION

Tower Hill is a volcanogenic landform near Warrnambool, Western Victoria, which has been called a nested caldera (Gill 1950, 1967, 1972), and a maar (Ollier & Joyce, 1964, Ollier 1967), and assigned an age 7300 ± 150 years B. P. (Gill 1972). It comprises an ash and lapilli rim encompassing a lake and several scoria cones. The rim is well defined in all but a small south-west portion and attains its highest development east-north-east of the ovoid main crater, which is elongated north-east to south-west and has long and short axes approximating 3.4 km and 2.6 km (Fig. 1). The rim extends outwards into a tuff apron, the areal asymmetry of which has been interpreted by Gill (1950, 1972) in terms of a prevailing south-west wind during the period of eruption. Ollier and Joyce (1964) have questioned this on the basis that the areal distribution of the tuff ring is not easily defined and asymmetry could reflect unusual winds engendered by the eruption.

The friable porous tuffs are extremely well bedded (e.g. Ollier 1967, figure 5), and display directional sedimentary structures. These comprise common climbing-ripple cross-lamination type B (Allen, 1973, figure 1) in ash horizons, and less common type A (op. cit.) in some small lapilli horizons. As defined by Allen, type A cross-lamination is characterized by an erosional relationship between sets, such that mainly lee-side laminae are preserved and the angle of climb is generally less than 10^2. In contrast, type B involves a gradational relationship between sets with preservation of stoss- and lee-side laminae, moderate to strong asymmetry of ripple profile, and angles of climb between 10^2 and 60^2.

Singleton and Joyce (1968) have suggested that foreset bedding in the tuffs is evidence of deposition from a slurry. They therefore disagree with wind-controlled asymmetry of the tuff ring (Gill 1950, 1972), and prior suggestions that the sedimentary structures are aeolian (Ollier & Joyce 1964, Marshall 1967).

This paper will present evidence for the aeolian origin of directional sedimentary structures at Tower Hill, and will examine Gill's proposal that the prevailing wind determined the asymmetric ash distribution.

STRUCTURAL ANALYSIS

Exposures from which meaningful structural data can be obtained are restricted to road metal quarries at five peripheral localities (Fig. 1). Bedding was systematically measured in each quarry and plotted as the plunge of the dip on a Lambert equal-area projection (Fig. 2). The radially outward initial dip (within the range 3^2 to 10^2) of the tuffs is readily apparent, despite lack of data from the south-west portion of the crater.

Directional sedimentary structures are common at locality 1, infrequent at locality 5 and sparse at localities 2, 3 and 4. This restricted the analysis to locality 1 where, for climbing-ripple cross-lamination types A and B, the dip of the lee- and stoss-sides, the angle of climb where the stoss-side was eroded, and the plunge of the crest (terminology after Allen 1973) were recorded. Resulting data were plotted on Lambert projections, and the most common orientations of measured elements were determined by visual assessment of point-distribution densities, since the relatively few readings did not merit contouring procedures. Monoclinic symmetry planes (or mirror planes) for cross-

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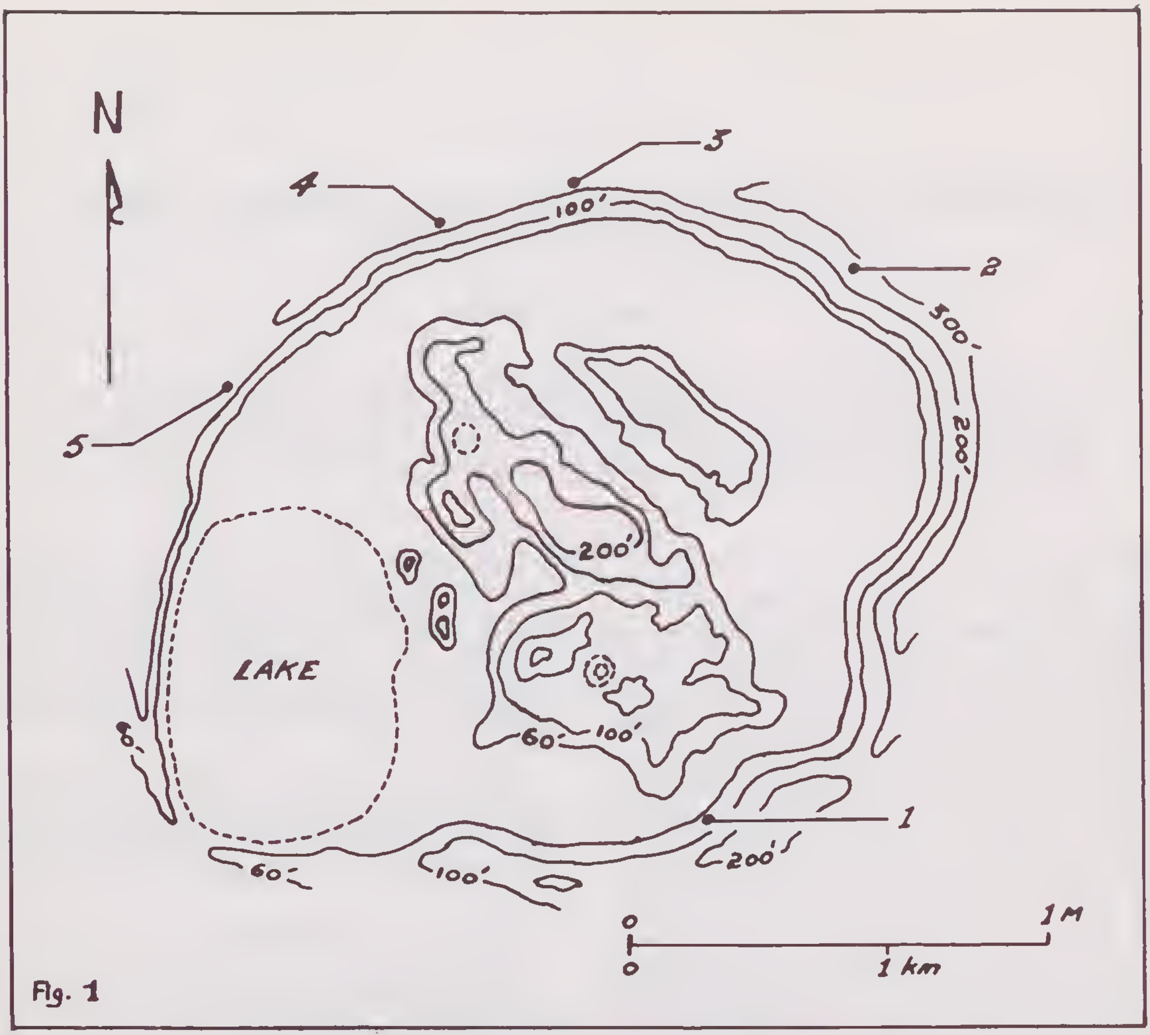


FIG. 1—Tower Hill: topographic contours and quarry localities (Nos. 1 to 5).

lamination types A and B were then constructed by finding which great circles of the projections were common to the lee- and stoss-side maxima.

The significance of determining the symmetry plane for climbing-ripple cross-lamination is that its strike is the trend of the aeolian or aqueous traction current which produced the structure. Further, the true movement-direction of the current may be obtained from the facing of lee-side laminae which are identified from ripple asymmetry.

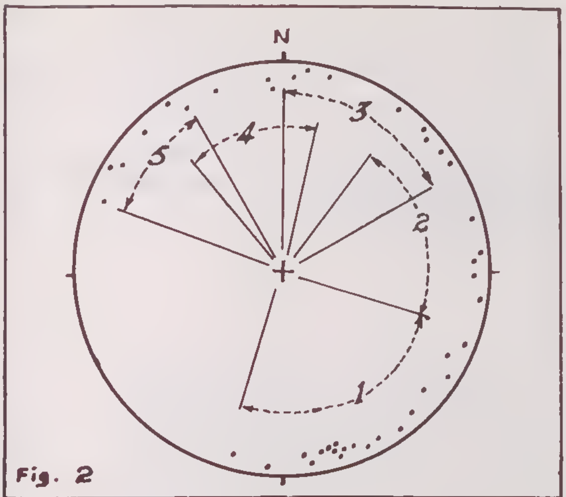
Excluding the plunge of ripple crests, which were measured to check the orientations of the symmetry planes and sensibly formed small peripheral concentrations about the poles to the symmetry planes, salient results are presented in Figs. 3A and 3B and Table 1.

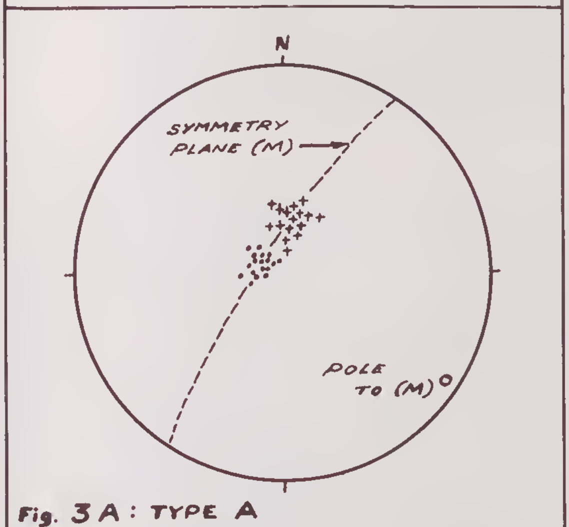
DISCUSSION

Despite the limited exposure and the small number of measurements, the analysis is considered meaningful because all exposed structures were recorded, the results are consistent, and the structural geometry is simple.

In Table 1 and Figs. 3A and 3B, the trend of the traction current producing the structures is the strike of the monoclinic symmetry plane, and the movement-direction within the trend is indicated by the facing of the lee-side element. For locality 1 where the tuffs dip south-south-eastward, the trend of climbing-ripple cross-lamination type A is 213^2-33^2 and the movement-direction towards 213^2; for type B the trend is 222^2-42^2 and the movement-direction towards 42^2. The trends of traction currents forming cross-lamination types A and B are therefore closer to the strike (approximately 045^2) than to the initial dip (135^2) of the tuffs, and the movement-vectors within the trends are very obliquely down the initial dip for type A, and very obliquely up the initial dip for type B.

These data are incompatible with the Singleton and





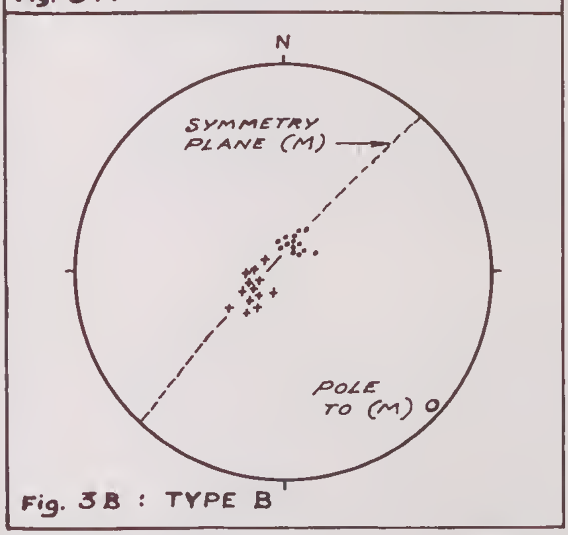


FIG. 2—Bedding plane orientations plotted as the plunge of the dip: the angular spread of data from each quarry is shown. FIG. 3A—Climbing-ripple cross-lamination type A: poles to lee (+) and stoss (.) sides. FIG. 3B—Climbing-ripple cross-lamination type B: poles to lee (+) and stoss (.) sides.

TABLE 1
THE MOST COMMON ORIENTATION OF STRUCTURAL ELEMENTS EXPRESSED AS:

Structural Element	Fig. 3A Strike	Fig. 3A Dip	Fig. 3B Strike	Fig. 3B Dip
Lee-side	279^2	19^{2}S	147^2	15^{2}NE
Stoss-side *or* angle of climb	202^2	8^{2}E	280^2	7^{2}S
Monoclinic symmetry plane (M)	033^2	82^{2}NW	042^2	86^{2}NW

Joyce suggestion that deposition was from a slurry, which would require the traction current vector to be down the initial dip of the tuffs, but support an aeolian genesis for the directional sedimentary structures.

Accepting an aeolian origin for the structures, climbing-ripple cross-lamination type B (the commonly observed form in this area) reflects a south-west wind from 22^2, whilst Type A was caused by a north-north-east wind from 33^2. The dominant wind trend therefore approximated north-east to south-west and, based on relative abundance of types A and B, the predominant wind direction during eruption was south-west. This direction is in accordance with the long axis of the elliptical crater, the build-up of substantial thicknesses of ash and tuff around the north-east sector, and, as noted by Gill (1950), the wider dispersion of the tuff and ash apron around the same sector. The results therefore support Gill's contention (1950, 1972) that the asymmetric tuff ring formed under the influence of a prevalent south-west wind, and accord with contemporary records (Hounam & Powell 1964) that the prevailing summer wind direction in the Warrnambool district is south-west.

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